

PROPOSAL

Port of Oakland

PROJECT TITLE: West Coast Regional Applied Ballast Water Management
Research and Demonstration Project

PRINCIPLE INVESTIGATOR: Maurya B. Falkner

AFFILIATION AND ADDRESS: California State Lands Commission
Marine Facilities Division
330 Golden Shore, Suite 210
Long Beach, CA 90802-4246

Phone: 562 499-6312 FAX: 562 499-6317
Email: falknem@slc.ca.gov

INSTITUTIONAL REPRESENTATIVE: Gary L. Gregory
Division Chief

AFFILIATION AND ADDRESS: California State Lands Commission
Marine Facilities Division
330 Golden Shore, Suite 210
Long Beach, CA 90802-4246

Phone: 562 499-6312 FAX: 562 499-6317
Email: gregorg@slc.ca.gov

DESIRED PROJECT PERIOD: January 1, 2001 to December 31, 2001

FEDERAL FUNDS GRANTED: \$150,000

PORT OF OAKLAND GRANT: \$150,000

PROGRAM AREA: Ballast Water Treatment and Management

SIGNATURES:

Maurya B. Falkner Date
Principle Investigator

Gary L. Gregory Date
Chief, Marine Facilities Division

PROJECT SUMMARY

INSTITUTION: California State Lands Commission

PROJECT TITLE: West Coast Regional Applied Ballast Water Management Research and Demonstration Project

PROJECT INITIATION DATE: 01/01/2001

PROJECT COMPLETION DATE: 12/31/2002

PRINCIPAL INVESTIGATOR: Maurya B. Falkner

AFFILIATION: Marine Facilities Division, California State Lands Commission

EFFORT: 7.0 MONTHS

CURRENT FEDERAL FUNDS (granted): \$150,000
PORT OF OAKLAND FUNDS (granted): \$150,000

SUGGESTED KEY WORDS: Ballast Water, Invasive Species, Management, Treatment

Project Summary

The introduction of invasive species through the discharge of ballast water is a major international problem that has resulted in significant physical, ecological, and economic impacts to a broad array of environments. Current efforts to prevent new introductions from ballast water discharges are widely considered inadequate. New methods of treatment are needed to solve the problem.

California State Lands Commission (CSLC) is collaborating with the State of Washington (WA) to develop a regional approach to make approved ballast water treatment systems available to the shipping industry. In August 2000, a grant from the U.S. Fish and Wildlife Service (USFWS) provided the CSLC funds for the analysis of a vessel by a marine engineering company to compare the feasibility and cost of installing an on-board ballast water treatment technology, versus retrofitting the vessel for ballast water discharge to a mobile treatment facility. Additional funds from the USFWS grant will aid the vessel owner in the retrofit of the on-board treatment equipment.

In October 2000 the Port of Oakland (POO) generously agreed to match those USFWS funds. The Port of Oakland funds will be used to bring an additional vessel into the West Coast Demonstration Project. Additionally, these moneys will aid in the analysis and subsequent development of standards for ballast water treatment technology.

CSLC will analyze the ballast water discharges from the vessels in coordination with State of Washington to develop and test standards for the discharge of treated ballast water. The information gained from this project will be used to educate vessel owners on ballast water treatment options and may be used to guide regulators on future legislation or regulations on this matter.

PROJECT DESCRIPTION

West Coast Regional Applied Ballast Water Management Research and Demonstration Project

Maurya B. Falkner

Marine Facilities Division, California State Lands Commission

GOAL AND OBJECTIVES

Goal: To reduce the risk of new invasive species introductions into the United States from the discharge of ballast water carried aboard commercial vessels.

Objectives:

- To provide well-researched cost estimates and proven ballast water treatment options to the maritime industry, permitting vessel owners to make informed decisions on the most appropriate type of ballast water treatment technology to utilize.
- To conduct applied research, in cooperation with the Port of Oakland, the California State Water Resources Control Board, California Department of Fish and Game, states of Washington, Oregon, and Alaska, U.S. Coast Guard, British Columbia, the maritime industry and ballast water equipment vendors, on practical, cost-effective methods of ballast water treatment for implementation on a state, regional, national, or international scale.

INTRODUCTION AND BACKGROUND

The introduction of marine and freshwater organisms into coastal marine and estuarine waters comes from a variety of sources, including aquaculture activities, aquarium trade, public aquaria, release by individuals, commercial, military, and recreational vessels, research institutions, and seafood commodity distribution (Elston 1997). However, because of the large volume and frequency of possible inoculations, ballast water from commercial vessels is currently the most frequently cited vector for the worldwide transference of nonindigenous aquatic species (NAS). Ballast water may contain an enormous number of diverse organisms. A recent study conducted on oil tankers arriving in Prince William Sound, Alaska found an average of 12,637 total organisms per cubic meter in the 169 vessels that were surveyed (Hines et al., 2000). The risk of introduction of NAS is significantly increased in recent times because vessels are faster and carry a tremendous amount of ballast water relative to ships just a few decades ago. For example, in the Great Lakes there were 90 known introductions during the 150 years between 1810 and 1959. In only 30 years between 1960 and 1990, there were 43 known introductions (Mills et al., 1993). This pattern is mirrored in the San Francisco Bay Estuary, where research indicates that prior to 1960 one new species became established about every 55 weeks. Since 1960, this has increased to one every 14 weeks (Cohen & Carlton 1998). Once introduced, invasive species are likely to become a permanent part of an ecosystem that can cause ongoing economic and environmental impacts. The best and most cost-effective method of addressing the problem of invasive species is to stop new introductions. Existing programs to manage ballast water introductions are widely considered inadequate. New invasive species introductions will continue to occur in every coastal port without the creation of new methods of managing ballast water discharges.

The zebra mussel (*Dreissena polymorpha*) is probably the best-known nonindigenous invasive species in the U.S. Since its accidental introduction to the Great Lakes via shipping in the 1980s, the zebra mussel has infested over 50% of U.S. freshwater waterways. Economic impacts, primarily associated with physically clearing the mussels from power station and other industrial cooling pipes, total \$5 billion annually (Pimentel et al., 1999). Of equal concern is the deleterious effect that the population explosion of the zebra mussel has had on the ecology of the Great Lakes, impacting numerous native species.

Another example, the Asian clam (*Corbicula fluminea*), was probably introduced via ballast water from Southeast Asia at the beginning of the 20th century, and is now found in 36 of the continental states. Although less studied than the zebra mussel, it actually may be the world's most invasive species. It is extremely efficient at filtering nutrients out of the water and therefore affects habitat nutrient dynamics. Few studies have been done on the ecological impacts on native biota, and there is no agreement as to whether or not they negatively impact native species. However, there has been considerable economic impact due to fouling of raw water systems, particularly power stations. The annual cost for control and repair efforts resulting from the Asian clam at these stations has been estimated at approximately \$1 billion (Isom 1986).

Introduction of marine species via ballast water is also of concern to the aquaculture industry. Aquaculture is the practice of raising aquatic organisms, such as clams, oysters, mussels, trout, salmon, etc. rather than harvesting them in their natural state. California and Washington states have a combined total aquaculture production of over \$100 million annually. Mollusks account for nearly \$33 million, while fishes and algae accounted for the remainder (USDA 1998). The NAS, European green crab (*Carcinus maenas*) first identified on the East Coast in the early 1800's, now ranges up the entire West Coast of the United States. This species preys on native crabs, clams, and small oysters, causing considerable damage to commercial shellfish beds. The economic impact nationwide is estimated to be \$44 million annually (Lafferty and Kuris 1996).

Ballast water has been documented to contain a number of pathogens causing economic impacts and public health concerns. In 1991, a strain of *Vibrio cholera* was found in the ballast water of three ships near Mobile, Alabama. Sometime thereafter, the bacterium was found present in local oysters (McCarthy and Khambaty 1994). A recent study of ballast water from vessel visiting the Chesapeake Bay showed *V. cholera* in planktonic samples collected from all ships (Ruiz et al., 2000). Ballast water and sediments can harbor toxic dinoflagellates, which cause paralytic shellfish poisoning (PSP) (Hallegraeff, 1998).

Recognizing the threat of new invasions from ballast water, the California State Legislature passed AB703 during the 1999 regular session to regulate ballast water discharges. Under Section 71210(a), the state is required to evaluate and put forward recommendations regarding alternative ballast water management technologies to reduce or eliminate the discharge of NAS into the waters of the state. This information is to be provided to the Legislature on or before December 31, 2002. Following suit, the Washington State Legislature passed SHB-2466 in 2000 to regulate ballast water discharges. Section 6 of this bill mandates the creation of the Washington Pilot Project. This Project is intended to make ballast water treatment available in Washington by July 1, 2002.

The mostly commonly used tool for ballast water management is open-ocean ballast water exchange. The intent of open-ocean exchange is to replace water taken on in nearshore environments with open-ocean water. Open-ocean ballast water exchange is currently the most

utilized management method because most vessels can conduct an exchange without vessel retrofitting. Ballast water exchange is also relatively inexpensive and can be done while the vessel is underway (Dames and Moore, 1999). However, ballast water exchange can result in dangerous vessel instability, putting the safety of the vessel and crew at risk (NRC, 1996).

The efficiency of ballast water exchange at removing entrained organisms is also a major concern. Original estimates of exchange efficiencies were as high as 99.9 percent. However, field tests have revealed efficiencies between 70 and 90 percent. Due to effectiveness and vessel safety concerns, open-ocean ballast water exchange is viewed as an interim solution, to be used until more effective treatment technologies are identified.

A variety of treatment technologies has been suggested for the removal or reduction of organisms found in ballast water. Numerous ballast water treatment technologies are under development. Laboratory tests alone cannot fully demonstrate the practical effectiveness of a treatment, and tests are needed on working vessels in real world situations. Additional information is needed on the availability of proven ballast water treatment methods, as well as engineering and cost estimates comparing the feasibility of onboard versus mobile treatment. This information will enable vessels to be retrofitted for testing treatment technologies in real world situations.

Justification

Ballast water is a major pathway for new introductions of NAS that can impact agriculture, aquaculture and many other industries. Every invasive species that is prevented from introduction is one that will not require funding for a control program or funding to mitigate for damages. This proposed cooperative project can significantly contribute to providing solutions that will reduce the risk of new introductions, and suppress the escalating cost of future control programs.

No single entity (state, federal or private) has the resources to adequately address the problem of NAS and ballast water management. To succeed we must form partnerships that combine our limited funds and authorities to accomplish large cooperative projects. California and Washington have demonstrated a commitment to being a part of the solution by passing legislation to control the discharge of ballast water. The state of California developed a ballast water discharge management program that went into effect January 1, 2000. Under the California law all vessels, United States and foreign, carrying ballast water into the waters of the state after operating outside the US Exclusive Economic Zone, are prohibited from discharging that water unless the shipper has complied with the discharge requires. Though the use of alternative treatment technologies is allowed under the law, no alternative technologies have been adequately tested or approved. Therefore, current treatment techniques are limited to mid-ocean exchange.

Three integrated research efforts are underway in the Pacific Coast Region. First is the currently funded West Coast Demonstration Project, which proposes to conduct an engineering evaluation and installation of alternative treatment technologies on one volunteer vessel (USFWS grant to CSLC). The second is the formation of a Research Team, assembled to provide an impartial analysis of ballast water treatment technologies (USFWS grant to University of Washington). The third, is the development of a laboratory testing facility to evaluate the effectiveness of new treatment technologies at eliminating NAS from ballast water (USFWS grant to Washington Department of Fish & Wildlife for the Washington Pilot Project).

Matching funds provided by the Port of Oakland to the CSLC will be used to retrofit and evaluate an additional volunteer vessel and assist in the development of ballast water treatment standards. Information resulting from these studies will permit the evaluation of ballast water treatment technology that will subsequently be made available to vessels operating in the region and worldwide. This information will provide them with means to be more proactive in minimizing or eliminating future introductions of NAS to their ports of call.

The success of the integrated regional projects (West Coast Demonstration Project, the University of Washington Project and the Washington Pilot Project) will depend upon the commitment of additional partners to contribute. Various private sector companies are writing proposals to provide ballast water treatment technologies for testing. Washington Department of Fish and Wildlife, is working with the U.S. Coast Guard, U.S. Fish and Wildlife Service, California State Lands Commission and the University of Washington to develop and fund a research program to test these new treatment technologies and assist in developing discharge standards for ballast water.

The funds from the Port of Oakland will result in an additional vessel able to participate in the West Coast Demonstration and Washington Pilot Projects and contribute to fulfilling the intent of the California and Washington state laws as well as the President's executive order on invasive species (Executive Order 13112, 1999).

Numerous ballast water treatment technologies are under development (hydrocyclone, UV light, Filtration, Ozone, etc.). However, very few have been tested on working vessels in real world situations to insure practicality, as well as effectiveness. Laboratory tests alone cannot fully demonstrate the practical effectiveness of a treatment methodology. Working vessels are needed to participate in the West Coast Demonstration Project. Volunteer vessels will have engineering studies completed on them for the retrofitting of their ballast water systems. The work to be conducted is experimental and will require time and effort from the vessel's owner and crew. The data gathered from this work will be of significant use to those seeking a solution to this international issue. Vessel owner's that are willing to participate in this project will receive some financial reimbursement for their participation in this experimental project.

RESEARCH AND TECHNICAL PLAN

Vessel Selection and Engineering Analysis

The USFWS grant will provide funding to analyze the feasibility, costs and benefits of installing on a vessel, flow-through ballast water treatment equipment versus retrofitting the vessel to allow ballast water treatment via a mobile treatment facility. The Port of Oakland matching funds will be used to leverage an addition vessel into this research effort.

Working with the maritime industry, US Coast Guard, Northeast-Midwest Institute, and other stakeholders, a list of potential volunteer vessels will be developed based in part on the criteria defined under Title 16USC Sec.4714 (3), which states that participating vessels must have ballast water systems conducive to testing aboard-vessel or land-based technologies and practices applicable to a significant number of merchant vessel; are publicly or privately owned, in active use for trade or other cargo shipment purposes; and be either majority owned by citizens of the United States or vessels that regularly call on ports in the United States. The potential list will be further refined based on the willingness of vessel owners to participate in the Washington Pilot Project and the trade route of the vessel. Once a vessel has been identified, and accepted as

meeting the aforementioned criteria, an engineering feasibility analysis will be performed to compare the installation of onboard treatment equipment versus retrofitting the vessel for mobile ballast water treatment.

This project intends to install on the volunteer vessels an on-board flow-through ballast water treatment system. A portion of the funds from this grant and matching Port funds will subsidize the cost of retrofitting and installing the equipment on them. Options for on-board flow-through ballast treatment systems will be selected based upon best available technology. Systems must be operationally practical; easily monitored by and safe for the vessel and crew; effective against a broad range of aquatic nuisance species; have reasonably low maintenance; be compact in size; economically feasible; and must have the potential to quickly deliver clean, environmentally safe ballast water from vessels.

Retrofit Evaluation and Monitoring

California State Lands Commission, U.S. Coast Guard and other appropriate organizations will monitor all vessel engineering designs and installations to insure regulatory compliance during the project. The vessel must be verifiably retrofitted to the marine engineering specifications created by the marine engineer. The appropriate authorities must inspect the vessel and evidence provided certifying approval of the retrofitting. Vessel owners must provide a written statement agreeing to participate in the West Coast Demonstration and Washington Pilot Projects to evaluate and monitor each ballast management system. Vessel owners must demonstrate proof of insurance and agree to hold the State of California harmless for any damages resulting from the retrofitting. Upon completion of the marine engineering study and the installation of a ballast treatment method aboard the vessel, the Washington Pilot Project and appropriate California state laboratories will be used to evaluate and monitor the technical merit (efficiency, safety, environmental soundness and effectiveness) of the ballast treatment system.

Project Evaluation and Monitoring Protocols

Detailed evaluation and monitoring protocols for testing flow through ballast treatment systems are in the process of being created. These protocols are being developed in collaboration with the California State Lands Commission, California Department of Fish and Game, California State Water Resources Control Board, U.S. Coast Guard, and the Washington Pilot Project Team Members. Once retrofitted, the vessel will participate in the Washington Pilot Project ballast water treatment research.

Final reports will be submitted to the USFWS, Port of Oakland, California State Water Resources Control Board, California Department of Fish and Game, Washington Department of Fish and Wildlife, maritime industry representatives and regulatory agencies throughout the nation. Additionally, the results of this work will be integrated into a study to be provided to the California State Legislature in late 2002.

OUTPUT/OBJECTIVES

Objective 1: California State Lands Commission, working with the regulated industry, the US Coast Guard, and other stakeholders, will identify volunteer vessels.

Objective 2: California State Lands Commission working in conjunction with the Northeast-Midwest Institute will contract with a marine engineering firm for implementation of this project on identified volunteer vessels.

The contractor will provide the Northeast-Midwest Institute and California State Lands Commission with a statement of work, detailing all project deliverables (output) including:

- A. Criteria for selecting the best available options for on-board flow through ballast treatment systems, including potential environmental impacts, and biological effectiveness information to be considered in selecting each of the best available options, assessment of crew training and safety requirements, and the proposed means for monitoring system use.
- B. Description and diagrams and the costs of the installation of the proposed system on the volunteer vessel so as to provide a comparison of the feasibility of onboard ballast water treatment versus mobile treatment
- C. Description of the detailed ballast system diagram that will be supplied to vessels that will be sufficient to enable vessels to be retrofitted for onboard treatment.
- D. Description of cost estimates, including: a) contract-level detailed cost estimates for installation or construction (specific source of shipyard rates); b) the estimated change in ship life-cycle cost considering capitol costs, and both positive (e.g. decreased fouling and sediment loads) and negative (e.g. slower or interrupted flow rate), operational impacts anticipated as a result of the treatment and retrofitted system, a 20 year life span for the vessel (unless the vessel type has an average life span significantly different than 20 years), voyage patterns, and a 10% interest rate.
- E. Statement of commitment to provide evidence that the proposed designs have been reviewed by the American Bureau of Shipping and U.S. Coast Guard and all comments incorporated or resolved.

Objective 3: Install on-board ballast water treatment system on volunteer vessel.

Objective 4: California State Lands Commission will partially reimburse the voluntary vessel owner for the cost of installing an on-board treatment system.

Objective 5: The California State Lands Commission will provide the information gained from the general design analysis to the Washington Pilot Project for use in reports and make it available for distribution nationally.

Objective 6: California State Lands Commission, in cooperation with the Washington Department of Fish and Wildlife, U.S. Coast Guard, California State Water Resources Control Board, California Department of Fish and Game and the vessel owners will monitor and evaluate the effectiveness of the onboard treatment technology equipment. The results will be included in

reports created by the West Coast Demonstration and Washington Pilot Projects and distributed nationally.

Objective 7: California State Lands Commission in consultation with the California Department of Fish and Game and the California State Water Resources Control Board, will prepare and submit a report for the United States Fish and Wildlife Service, Port of Oakland on the results of this project.

TIME TABLE

Grant Awarded	California State Lands Commission, working with the regulated industry, the Northeast-Midwest Institute, Port of Oakland, the US Coast Guard, and other stakeholders, will identify volunteer vessels (Objective 1). California State Lands Commission working in conjunction with the Northeast-Midwest Institute will contract with a marine engineering firm to provide funding for the implementation of this project proposal as described in the budget (Objective 2).
February 2001	the Contractor will begin a general design analysis for the volunteer vessel (Objective 2).
April 2001	the Contractor will begin a detailed design analysis for the volunteer vessel to be retrofitted for discharge to a mobile treatment facility (Objective 2).
July 2001	Installation of on-board ballast water treatment system on volunteer vessel (Objective 3). California State Lands Commission will partially reimburse the vessel owner(s) for the cost of installing an on-board treatment system (Objective 4). California State Lands Commission, in cooperation with the Washington Department of Fish and Wildlife, U.S. Coast Guard, California State Water Resources Control Board, California Department of Fish and Game and the vessel owners will monitor and evaluate the effectiveness of the onboard treatment technology equipment as part of the West Coast Demonstration and Washington Pilot Projects (Objective 6).
December 2001	California State Lands Commission will produce an annual report identifying milestones for each project year, progress to date on carrying out the objectives and funds spent to date. The report will be submitted to U.S. Fish & Wildlife Service and Port of Oakland.
December 2001	The Northeast-Midwest Institute and California State Lands Commission will provide the information gained from the general design analysis to the Washington Pilot Project for use in their reports (Objective 5).

July 2002 California State Lands Commission in consultation with the California Department of Fish and Game and the California State Water Resources Control Board, will prepare and submit a report for the United States Fish and Wildlife Service, and the Port of Oakland on the results of this project (Objective 7).

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USDA. 2000. 1997 Census of Agriculture, AC97-SP-3, Census of Aquaculture (1998), Volume 3, Special Studies, Part 3. February 2000.

DRAFT

VITAE

Name: Maurya Bridget Falkner

Title: Environmental Specialist IV
Program Manager, Ballast Water Management Program

Affiliation: Marine Facilities Division, California State Lands Commission

Telephone: (562) 499-6312 (day) **FAX:** (562) 499-6317

Email: falknem@slc.ca.gov

EDUCATION

MS. Colorado State University (CSU), Forest Ecology/Conservation Biology. Thesis: Comparing the Life History Characteristics of Three Species of Hawaiian Tetramolopium.

BS. Colorado State University, Zoology/Animal Biology.

POSITIONS HELD (1990 – present)

Environmental Specialist VI, California State Lands Commission. 1996 - present

Research Associate, NREL. Colorado State University. 1992 - 1997

Research Associate, Dept. Forest Science, Colorado State University. 1990 - 1992

PROFESSIONAL MEMBERSHIPS

American Association for the Advancement of Science, American Institute of Biological Sciences, Ecological Society of America

PUBLICATIONS

Aplet, G.H., R.D. Laven, M.B. Falkner, and R.B. Shaw. 1994. Population and Site Characteristics of a Recently Disjunct Population of *Croton alabamensis*. *Sida* 16(1):37-55.

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RECENT INVITED MEETING PRESENTATIONS

Falkner, M.B. Existing and Potential Techniques for Verifying Open Ocean Exchanges. May 2000. Vessels & Varmints: A Workshop on the Next Steps for Ballast Water Management in the San Francisco Estuary.

Falkner, M.B. California's Ballast Water Management Program. August 2000. Prevention First 2000.

Falkner, M.B. California's Ballast Water Management Program. September 2000. Annual meeting of the Western Regional Panel of the Aquatic Nuisance Species Task Force.